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Prairie & Grasslands Edition

ESTABLISHING WILDFLOWERS AFTER HERBICIDE APPLICATION

by Mark Renz, Mike Moechnig, and Mary Halstvedt

Efforts to restore or rehabilitate mixed wildflower (forb)-grass prairie landscapes in the Midwestern United States are often compromised by the presence of invasive plants.

While herbicides provide effective control of invasive plants, they are often not used due to concern that herbicide residues may persist in the soil and impact establishment of wildflowers. Researchers in Wisconsin and South Dakota examined the response of common native wildflower species seeded in the fall or spring following treatments with Milestone® and Transline® herbicides. The results of this research provide promise for land managers balancing invasive plant control and restoring desirable prairie habitat.

Native tallgrass prairie historically included a mix of grasses such as big bluestem (*Andropogon gerardii*) and Indiangrass (*Sorghastrum nutans*), along with native wildflowers such yellow coneflower (*Ratibida pinnata*) and wild bergamot (*Monarda fistulosa*). These ecologically important prairies provide food and shelter for a wide variety of wildlife species. It is estimated that more than 99 percent of native tallgrass prairie has been destroyed or severely impaired in the Midwestern United States, highlighting the importance of efforts by public and private land managers to restore or rehabilitate mixed wildflower-grass prairie systems in this region.

Invasive plants such as Canada thistle (*Cirsium arvense*) can greatly impact the success of seeding both grasses and wildflowers. Although, best management practices recommend the application of herbicides to control noxious and invasive weeds prior to establish-

["WILDFLOWERS" continued on page 2]

IN THIS ISSUE

["WILDFLOWERS" continued from page 1]

ing mixed grass prairie systems, there is concern about the effect of herbicide residues on wildflower establishment.

In 2009, Dr. Mark Renz, University of Wisconsin and Dr. Mike Moechnig, South Dakota State University teamed up on a research project to determine the tolerance of common desirable prairie wildflowers to herbicide applications. Land managers identified this research as an important requirement for restoring native prairie due to the high cost of native wildflower seed and lack of information on the tolerance of wildflowers to herbicides applied prior to planting. The objective of the study was to determine if herbicides applied the summer prior to planting would reduce establishment of common wildflowers in mixed prairie plantings seeded in fall and the following spring.

Figure 1. Map showing location of study sites

Table 1. Milestone and Transline application timing and seeding dates for forbs at two study locations.

Study Location	Herbicide Application	Seeding Dormant FALL	Seeding SPRING
South Dakota Northern Tallgrass Prairie	Jul. 22 2009	Nov. 17 2009	Apr. 16 2010
Wisconsin Prairie-Forest Border	Jul. 07 2009	Nov. 16 2009	Apr. 28 2010

METHODS

The study sites were located at university research farms in Arlington, Wisconsin and Beresford, South Dakota. The site in South Dakota is located in the southeast part of the state within the Northern Tallgrass Prairie ecoregion, and the site in Wisconsin is in the Prairie-Forest Border ecoregion in the southcentral part of the state (**Figure 1**). The research sites were in either annual or perennial cropping systems prior to the study. Fields were chisel plowed then disked to prepare the seed bed (Wisconsin) or in a no-till system (South Dakota) prior to herbicide application. Experiments were established as a split-plot design with four replications of each treatment. Milestone and Transline were applied in July 2009 (mid-summer treatment). Glyphosate was applied to the study area to control annual weeds and dandelions prior to seeding. Wildflower species (**Table 4**) were planted with a no-till drill as a dormant fall planting in November four months after herbicide treatment (**Table 1**). With a dormant seeding, wildflowers are planted in the fall just before the soil freezes. The seed remains dormant in the soil until the following spring when they will germinate and grow as soon as conditions are favorable. The spring seeding date was in April, approximately nine months after herbicide treatment. Annual weedy grasses were controlled at both sites by applying grass-specific herbicides and mowing in 2010 in Wisconsin.

Researchers designed the study to evaluate if Milestone and Transline herbicides influenced establishment of common prairie wildflowers planted in the fall as a dormant planting or the following spring. Density of planted species was measured 12, 18, and 24 months after application. Species within each site were analyzed separately by location by analysis of variance ($p<0.05$). Although various herbicides, rates, and combinations were applied in the experiment, results discussed below include the maximum broadcast use rate of Milestone® at 7 fluid ounces per acre (fl oz/A) and Transline® at 16 fl oz/A.

There was either no difference or an increase in wildflower density from herbicide treatments in 86% of the species seeded in the study compared to non-treated controls. Black-eyed Susan was the only species showing a decline in density when treated with Transline in Wisconsin, but not in South Dakota.


Wendy VanDyk Evans, bugwood.org

Table 2. Black- eyed Susan was the only wildflower seeded in WISCONSIN showing a decline in density (plants per meter row) 24 months after treatment with Transline at 16 fl oz/A. *Indicates a significant difference in density compared to non-treated control $p<0.05$.

	PLANTS PER METER ROW
Herbicide	Black-eyed Susan
Milestone 7 fl oz/A	1.3
Transline 16 fl oz/A	0.4*
Non-treated control	1.6

Table 3. Wildflowers planted in SOUTH DAKOTA showed either no response or significantly greater density in response to Milestone at 7 fl oz/A and Transline at 16 fl oz/A 24 months following application. *Indicates density was significantly different compared to the non-treated control ($p<0.05$). There was no difference in plant density as a result of herbicide treatment for other wildflowers not shown in this table.

	PLANTS PER METER ROW			
Herbicide	Prairie Coneflower	Black-eyed Susan	Canada Milkvetch	Wild Bergamot
Milestone 7 fl oz/A	3.3*	2.8	1.3*	3.0*
Transline 16 fl oz/A	3.0*	3.4*	1.8*	3.9*
Nontreated Control	1.6	2.0	0.4	1.3

Table 4. Effect of dormant fall and spring planting date on wildflower density 24 months after seeding in Wisconsin and South Dakota. *Indicates a difference in plant density as a result of planting date at each location ($p>0.05$).

		Wisconsin		South Dakota	
		PLANTS PER METER ROW			
Species	Study Location	Fall	Spring	Fall	Spring
Black-eyed Susan *Rudbeckia hirta*	Wisconsin South Dakota	0.6*	1.1	2.4	2.9
Lance leaved coreopsis *Coreopsis lanceolata*	Wisconsin South Dakota	0.2*	3.7	1.4*	4.2
Blanketflower *Gaillardia pulchella*	Wisconsin South Dakota	0.1*	0.2	0.7*	1.9
Wild Bergamot *Monarda fistulosa*	Wisconsin South Dakota	1.0*	1.8	3.6*	1.9
Smooth blue aster *Aster laevis*	Wisconsin	1.6	2.4		
Yellow coneflower *Ratibida pinnata*	Wisconsin	2.5	2.2		
Purple coneflower *Echinacea purpurea*	Wisconsin	1.9*	3.1		
Round headed bush clover *Lespedeza capitata*	Wisconsin	0.1*	0.6		
Purple prairie clover *Dalea purpurea*	South Dakota			0.2*	1.8
Prairie coneflower *Echinacea pallida*	South Dakota			3.5*	1.8
New England aster *Aster novae-angliae*	South Dakota			0.3	0.4
Illinois bundleflower *Desmanthus illinoensis*	South Dakota			0.4*	1.4
Canada milk-vetch *Astragalus canadensis*	South Dakota			1.6*	0.6
Golden alexander *Zizia aurea*	South Dakota			1.6*	1.7

RESULTS

Results from the study showed that specific wildflower species varied in response to timing of planting and herbicide treatment (**Tables 2, 3,** and **4**), but rarely did both factors interact to change wildflower density.

- Black-eyed Susan density was reduced by Transline® at 16 fl oz/A at Wisconsin but not in South Dakota when compared to the non-treated plots 24 months after treatment.
- There was either no difference or an increase in wildflower density from herbicide treatments in 86% of the species seeded in the study compared to non-treated controls.
- In Wisconsin, the spring planting date resulted in significantly more plants per meter row for blanket flower, black-eyed Susan, wild bergamot, lance leaved coreopsis, round headed bush clover and purple coneflower ($p<0.05$).
- There was no interaction between planting date and herbicide treatment. Differences in wildflower establishment by planting date may be due to biotic factors such as seed depredation.

Results suggest that many native wildflowers can be seeded as a dormant fall planting or the following spring following a summer application of Milestone and Transline at rates evaluated (**Table 4**). These herbicides are also safe to grasses, providing additional management tools for improving the success of restoring mixed wildflower-grass prairies.

EDITORS NOTE:
This article summarizes a paper presented at the 66th annual meeting of the North Central Weed Science Society (December 12-15, 2011; Milwaukee, WI) by Mark Renz, Mike Moechnig, and Mary Halstvedt. **http://ncwss.org/proceed/NCWSS-2011-Proceedings.pdf**

by Celestine Duncan, TechLine Editor

US Fish and Wildlife Service Manages Invasive Woody Plants

The Litchfield Wetland Management District (WMD) lies in the transitional zone between native woodland and prairie. Encompassing more than 40,000 acres of private and U.S. Fish and Wildlife Service-owned lands in south-central Minnesota, these protected prairies, marshes, and woodlands provide habitat for waterfowl, grassland birds, and other wildlife species. The blending of woodland and prairie biomes provides habitat for a variety of wildlife species, but also increases the risk of woody plant encroachment in prairie and grasslands.

"Our remnant tallgrass prairies are in a true warzone with woody plants," explains Scott Glup, project leader on the Litchfield WMD. "Historically, wildfire and large herds of bison maintained open prairies. The loss of these natural forces, human-cause disturbance, and the introduction of non-native trees combine to threaten the existence of our remnant prairie." For several years, the U.S. Fish and Wildlife Service has partnered with the Minnesota Department of Natural Resources, Pheasants Forever, The Nature Conservancy, National Fish and Wildlife Foundation, and other government and private partners to enhance and protect the vanishing northern tallgrass prairie in western Minnesota and northern Iowa. "Today less than one percent of the tallgrass prairie, or about 300,000 acres in the two states, remains under protection," explains Glup. This makes it one of the rarest and most fragmented ecosystems in North America and imperils the survival of prairie-dependent grassland birds and other prairie wildlife.

Scott Glup, project leader on the Litchfield Wetland Management District, explains that tallgrass prairie is one of the rarest and most fragmented ecosystems in North America. Protecting and preserving grasslands from invasive woody vegetation can greatly improve the quality of habitat for grassland wildlife.

Research has shown that encroachment of woody vegetation into prairie grassland has a negative impact on the occurrence, density and/or nesting success of game and nongame grassland nesting birds. "It's important to protect and preserve our grasslands from invasive woody vegetation," says Glup. "We believe that by strategically removing encroaching trees we can greatly improve the quality of habitat for grassland wildlife." The non-native trees and shrubs targeted for removal include invasive species such as Siberian elm (*Ulmus pumila*), buckthorn (*Rhamnus cathartica*), honeysuckle (*Lonicera* spp.), and Siberian pea shrub (*Caragana arborescens*), as well as trees native to North America like green ash (*Fraxinus pennsylvanica*), cottonwood (*Populus deltoides*) and red cedar (*Juniperus virginiana*). Removing trees opens

Four Minnesota biomes. Circle indicates approximate location of Litchfield Wetland Management District in the transitional zone between woodland and prairie.

EDITORS NOTE:
An annotated bibliography on The Effect of Woody Vegetation on Grassland Nesting Birds by Kristel K. Bakker, College of Arts and Sciences, Dakota State University Madison, SD 57042 (updated 2008) can be requested by emailing **diane_granfors@fws.gov**.

Photos taken before (left) and after woody species removal at Weber Waterfowl Production Area (WPA)

the landscape to provide more suitable habitat for birds that need large grassland blocks for breeding. The woody vegetation also attracts predators so removal of those plants gives grassland nesting birds a better chance to successfully rear their young.

"We aren't trying to remove all the trees in our district," explains Glup. Many of the Waterfowl Production Areas (WPAs) in the Litchfield WMD have native woodlands with stands of oak (*Quercus* sp.), basswood (*Tilia* sp.), and black cherry (*Prunus serotina*). The tree removal project protects these original oak savannahs from invading trees. In many cases wildlife that use wooded areas are common and their populations are not threatened. Because grasslands and shallow wetlands are much less common, survival of plants and wildlife that rely on this habitat are threatened [Box 1].

Nick Palaia, wildlife biologist on the Litchfield WMD plans, coordinates, and monitors woody vegetation control efforts. "We use a lot of different methods to manage invasive trees and shrubs in our grasslands including fire, which is very effective on invading red cedar. The problem is that fire doesn't provide good control of deciduous trees, so we use a variety of methods alone and in combination with herbicide treatments, and livestock grazing to maintain open grasslands," explains Palaia.

Grasslands are prioritized for tree removal based on size of the grassland, wildlife habitat value, and potential for long-term protection from encroaching woody invaders. Thousands of acres of prairie have been protected from invasive woody trees since 2005 when the District expanded their tree removal program. Tree removal is done in all seasons; however the bulk of work in the Litchfield WMD is done later in the year. Fall and winter are optimum times to remove trees because soils tend to be firm and dry in fall, or frozen in winter, which reduces damage from heavy equipment. There is also less impact to wildlife such as nesting birds.

What methods has the Litchfield WMD found most effective for selectively controlling trees? "It depends on the tree species, size of the tree and density of the infestation," explained John Haffley, biological technician on the WMD. "When you cut down red cedar the tree is killed. But green ash, elm, cottonwood and box elder will re-sprout, so herbicide treatments immediately following cutting are important for complete control." The district uses a 20% solution of Garlon® 4 Ultra (2 quarts Garlon 4 Ultra to 2.5 gallons bark oil) for most of their cut stump treatments. Box elder proved more difficult to control, so in 2010 the District started including Milestone® in combination with Garlon 4 Ultra to stop re-sprouting. "We mixed 0.5 to 1.0 fl oz of Milestone and 2 quarts of Garlon 4 Ultra to 2.5 gallons of bark oil and were able to get much better control of re-sprouting on box elder," says Haffley.

Private contractor Curt Plotz agrees that it's important to treat the cut stump as soon as possible. "We apply the herbicide solution in a continuous ring around the tree stump including any areas where the bark is torn away," Plotz explains. "It's important to get good coverage of the cambium and bark layer with herbicide solution to stop any re-sprouting. Using Garlon 4 Ultra and this treatment method, we haven't had to go back and re-treat any stumps."

["USFWS" continued on page 6]

BOX 1

ATTRACTING GRASSLAND BIRD POPULATIONS

Grassland bird populations are declining more rapidly than any other group of North American birds. Nesting passerine species such as savannah sparrow (*Passerculus sandwichensis*), grasshopper sparrow (*Ammodramus savannarum*), bobolink (*Dolichonyx oryzivorus*), and western meadowlark (*Sturnella neglecta*) consistently show negative responses to woody vegetation at all levels. Negative associations with woody vegetation have also been found with ducks and pheasants. The hope is to attract some of these species through elimination of woody vegetation.

Western Meadowlark
(Photo by Terry Spivey, USDA Forest Service, Bugwood.org)

["USFWS" continued from page 5]

The Dymax shear mounted on a skid steer is used to cut larger trees and apply herbicide to the cut stump.

District employees and contractors utilize tools ranging from hand clippers to large equipment for controlling encroaching trees. The Dymax shear mounted on a skid steer is used to cut large trees six to 16 inches in diameter at ground level and apply herbicide to the cut stump. "This piece of equipment is almost indestructible, it cuts large trees and applies herbicides to the cut surface at the same time," says Haffley. The shear saves time and resources since there is no follow up with a separate herbicide treatment. Other equipment, including a carbide cutter that grinds trees up to three to four inches in diameter, and a timber ax are more effective on high density stands (thickets) of invasive woody shrubs like buckthorn and small trees. Haffley explains, "The timber ax cuts cleaner but is not as rugged as the carbide cutter and needs to be used in rock-free landscapes." Once thickets of small trees are cut, they are allowed to re-sprout and the canopy is broadcast sprayed with either Garlon® 4 Ultra alone or a mixture of Garlon 4 Ultra and Milestone either in July following cutting in winter, or in the fall following summer removal.

Special funding for control of non-native trees and woody plantings allow the Litchfield WMD to remove trees in abandoned windbreaks and around homesteads, which are a seed source continually re-infesting adjacent grasslands. These were some of the first areas that the Litchfield WMD targeted for removal. Private tree-removal contractors are encouraged to send commercial logs to a mill for use as building material, or use wood from smaller trees as biomass to produce energy. Recent technological advances in renewable energy are increasing the feasibility of utilizing wood from these habitat restoration projects.

The Litchfield WMD is protecting and improving the quality of prairie fragments for prairie-dependent wildlife through well-planned tree removal. Long-term management to prohibit re-infestation by trees includes diligent use of a variety of management techniques such as periodic fires to maintain historic prairie landscapes. "The Litchfield WMD aggressive prairie restoration effort is based on the best available science and the need to restore habitat for dwindling prairie wildlife," says Glup.

Scout volunteer pulling buckthorn out of a native stand of burr oak on the Weber WPA

BOX 2

SCOUTS TACKLE WOODY PLANTS

Scott Glup is a firm believer in partnerships. Through his efforts with a local Boy Scout troop, the Scouts, parents and Scout leaders have donated more than 1,000 hours removing invasive buckthorn and other undesirable trees on grassland and oak savannah within the Litchfield Wetland Management District. The volunteers arm themselves with gloves, tree pullers, loppers and other tools to remove invading brush and trees. "Typically the Scouts are 14 to 18 years old, but we've had volunteers as young as 10 and 11," explains Glup. "The Scouts hand-pull small invading trees such as buckthorn and honeysuckle, or use clippers or mechanical pullers on trees up to six feet tall." Results from work conducted by the Scouts, show that woody sumac cover and density is greatly reduced when plants are clipped to ground level for three to four consecutive years. In addition, Scouts also planted native wildflowers and grasses, planted native ecotype burr oak (*Quercus macrocarpa*) as part of the savanna restoration project, picked up litter and trash along several miles of road side, and restored or established new interpretive signs and other projects. "The motivation, dedication and spirit of these kids leave me feeling good about the future of land management," says Glup.

At a ceremony held in Washington, D.C., Scott Glup was honored as the 2009 Federal Land Manager of the Year from Take Pride in America®, for his dedication toward fostering the appreciation and stewardship of public lands with Boy Scouts.

COMPARISON OF GREENHOUSE TO NATIVE GROWN WILDFLOWERS

for Milestone® Herbicide Tolerance

by Jonathan R. Mikkelson and Rodney G. Lym ; North Dakota State University, Fargo.*

Tolerant species such as purple coneflower (left) quickly recovered from initial injury, whereas prairie coneflower (right) was severely injured or killed by low rates of Milestone.

The preservation of native wildflowers (forbs) is important for plant community function and diversity, and provides food and cover for wildlife. Field studies have been conducted throughout western states to determine the impact of herbicides applied to control invasive weeds on native plants.

However, finding adequate native wildflower populations to evaluate their tolerance to herbicide applications is often difficult. A greenhouse study to evaluate the tolerance of nine native prairie wildflowers to Milestone herbicide was established at North Dakota State University. The species included in this study were representative of common native prairie plant families that could not be evaluated in field trials because of their rarity or tendency to grow singularly in the wild. The species chosen were harebell (*Campanula rotundifolia* L.), white prairie clover (*Dalea candida* Michx. ex Willd.), purple coneflower [*Echinacea purpurea* (L.) Moench], blanket flower (*Gaillardia aristata* Pursh), closed bottle gentian (*Gentiana andrewsii* Griseb.), great blue lobelia (*Lobelia siphilitica* L.), prairie coneflower [*Ratibida columnifera* (Nutt.) Woot. & Standl.], showy goldenrod (*Solidago speciosa* Nutt.), and azure aster (*Symphyotrichum oolentangiensis* Riddell).

METHODS

The prairie wildflowers used in the study were obtained from a commercial nursery and transplanted into conetainers filled with a commercial potting media and sandy loam soil. Plants were grown approximately 20 to 32 weeks in a greenhouse with temperature and lighting regulated to simulate field conditions and initiate flowering in wildflowers. Plants were treated with Milestone at the approximate growth stage found under field conditions for a fall application timing to control Canada thistle. Milestone at 1.75, 3.5, and 7 fluid ounces of product per acre (fl oz/A) was applied with an air-pressurized greenhouse cabinet-type sprayer. A non-ionic surfactant at 0.25% v/v was added to the herbicide solution to maximize potential wildflower injury and simulate a typical broadcast application in the field. Plants were visually evaluated for injury 1, 7, and 14 days after treatment. Following the 14-day rating, the top growth was removed and plants were allowed to regrow for 5 to 8 weeks. Visual percent injury was taken at 7 to 9 weeks after treatment (WAT) (**Table 1**). Plant regrowth was clipped following visual evaluations and weighed to estimate the long-term effect of Milestone® on plant production (**Table 2**).

["GREENHOUSE" continued on page 8]

Plants were grown approximately 20 to 32 weeks in a greenhouse with temperature and lighting regulated to simulate field conditions and initiate flowering.

Plants were visually assessed for injury then clipped and weighed to estimate long-term effect of Milestone on plant production.

*Jonathan R. Mikkelson is a former graduate student that received his MS degree with Dr. Rod Lym, Professor, Plant Sciences Department, North Dakota State Univ. in 2010.

["GREENHOUSE" continued from page 7]

Table 1. Percent visual injury observed on various greenhouse grown wildflowers 7 to 9 weeks after treatment with Milestone at 0, 2, 3.5, and 7 fluid ounces of product per acre.

	% Injury Milestone Rate (oz/ac)			LSD	
Species Family	2	3.5	7	(0.05)*	Susceptibility Rating**
Azure aster Asteraceae	1	1	1	NS	Tolerant
Blanket flower Asteraceae	11	25	23	16	Moderately Tolerant
Purple coneflower Asteraceae	1	6	14	NS	Tolerant
Prairie coneflower Asteraceae	75	96	100	20	Susceptible
Showy goldenrod Asteraceae	5	3	10	NS	Moderately Tolerant
Great blue lobelia Campanulaceae	73	76	78	14	Moderately Susceptible-Susceptible
Harebell Campanulaceae	95	100	99	12	Susceptible
White prairie clover Fabaceae	95	99	100	7	Susceptible
Closed bottle gentian Gentianaceae	1	4	28	13	Tolerant

*Data analysis: Plant injury ratings and regrowth weights were evaluated using PROC GLM procedure of SAS4 to determine differences in injury, and F-protected LSD (P = 0.05) tested mean separation. Error mean squares from each run were compared for homogeneity of variance. A combined analysis was conducted when error mean squares for each run differed by less than a factor of 10. [NS=not significant]

**Tolerant: Minimal symptoms—may exhibit slight injury and cupping of leaves. <15% stand reduction.
Moderately tolerant: Cupping/yellowing and possible inhibited flowering with recovery the first growing season after application. 15 to 50% stand reduction.
Moderately susceptible: Significant injury the first year and possible stand reduction. 51 to 75% stand reduction.
Susceptible: Severe injury the season of application and stand reduction the year after treatment with possible death of established plants. Some plants may regenerate from seed bank. >75% stand reduction.

Table 2. Weight in grams of various greenhouse grown wildflowers harvested 7 to 9 weeks after treatment with Milestone at 0, 2, 3.5, and 7 fluid ounces of product/acre.

	Weight in Grams Milestone Rate (oz/ac)				LSD
Species	0	2	3.5	7	(0.05)*
Azure aster	0.9	0.6	0.5	0.4	NS
Blanket flower	1.4	1.4	0.5	0.6	NS
Purple coneflower	5.1	5.4	3.7	3.4	NS
Prairie coneflower	1.7	0.4	0	0	1.1
Showy goldenrod	1.2	0.7	0.6	0.2	1.2
Great blue lobelia	0.8	0.2	0.1	0.1	0.5
Harebell	0.7	0	0	0	0.4
White prairie clover	0.4	0	0	0	0.1
Closed bottle gentian	0.7	1.1	0.8	0.4	NS

RESULTS

Prairie wildflower susceptibility to Milestone® varied by species. Purple coneflower, closed bottle gentian, and azure aster were tolerant to Milestone (**Table 1**) and quickly recovered from initial injury (if any). Although azure aster was tolerant to Milestone in this study, similar Asteraceae species have shown variable tolerance to fall-applied Milestone in the field (Almquist and Lym 2010, Samuel and Lym 2008). Closed bottle gentian was moderately tolerant to Milestone at 3.5 to 7 fl oz/A. Injury for this species tended to increase as the application rate of Milestone® increased (**Table 2**). Milestone will likely not adversely affect closed bottle gentian in the long-term.

Blanket flower and showy goldenrod were moderately tolerant to Milestone. Field studies in prairie plant communities suggest that Milestone may cause injury to *Solidago* species. Milestone applied in the fall at 7 fl oz/A reduced foliar cover of Canada goldenrod (*Solidago canadensis* L.) and Missouri goldenrod (*Solidago missouriensis* Nutt.) 22 months after treatment in prairie plant communities in Minnesota (Almquist and Lym 2010) and North Dakota (Samuel and Lym 2008). Velvety goldenrod (*Solidago mollis* Bartl.) foliar cover was reduced by more than 75% compared to the untreated control 10 months after Milestone® was applied (Almquist and Lym 2010). These results suggest that these *Solidago* species were more sensitive to Milestone than showy goldenrod, or there had not been adequate time for plants to fully recover by 10 or 22 MAT. Although both blanket flower and showy goldenrod were slightly injured by herbicide treatments in the greenhouse study, plants would likely recover by the following growing season.

Milestone severely injured or killed harebell, white prairie clover, great blue lobelia, and prairie coneflower when applied at rates as low as 1.75 fl oz/A. Similar results for prairie coneflower have been reported in earlier research when Milestone was applied in fall to a western North Dakota native plant community (Samuel and Lym 2008). Although Milestone caused severe injury to great blue lobelia, most plants

were alive 7 WAT so the species may have been able to recover over time. In a Minnesota field study, palespike lobelia (*Lobelia spicata* Lam.) was injured, but not killed by Milestone® at 7 fl oz/A (Almquist and Lym 2010). Although foliar cover was reduced, Milestone did not eliminate palespike lobelia from the prairie plant community even when applied at the maximum use rate of 7 fl oz/A.

CONCLUSION

This information is valuable to land managers who are tasked with balancing the benefits of a Milestone application to control invasive weeds with the potential of unintentional injury to desirable wildflower species. The results of this greenhouse study expand and support data from field studies on susceptibility of native wildflowers to Milestone applications. Wildflower species that were tolerant to Milestone in the greenhouse likely would be tolerant in the field. Additional information on plant tolerance to Milestone® application can be found at http://techlinenews.com/ForbShrubToleranceto Milestone.pdf.

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CORRECTION

In the article, "Native Grass Establishment Following Herbicide Applications" (Fall 2011), seeding dates for North Dakota and Minnesota were incorrect in Table 1. The correct dates are April 22 for North Dakota and November 17 for Minnesota . Thank you, Dr. Rod Lym, for bringing this to our attention.

OPTIMAL HERBICIDE APPLICATION TIMING FOR

Canada Thistle Control

by Darrell Deneke, Mike Moechnig, Dave Vos, and Jill Alms, South Dakota State University, Brookings

Canada thistle (*Cirsium arvense*) is a widespread noxious weed throughout the prairie regions of the Midwestern United States. Selective herbicides provide effective control if applied at the early bud growth stage (late June) or at fall re-growth stage (mid-September to October), preferably after a light frost. However, there are few recent studies evaluating the effect of herbicide application time on Canada thistle control.

Field studies were established on Canada thistle in two counties in eastern South Dakota. Herbicide treatments included a fall application of Milestone® at 5 and 7 fluid ounces per acre (fl oz/A) and Tordon® 22K at 1 pint per acre (pt/A) applied in September, October or November in 2007 in Brookings and Clark Counties. A summer application of Milestone at 5 and 7 fl oz/A was also applied at multiple times from May through October in 2009 in Clark County. Plot design was a randomized complete block with three replications of each treatment. Evaluations of herbicide treatments were made one year following treatment. Control was determined from visual estimates of Canada thistle shoot growth reduction relative to the non-treated control. Treatment means were compared using analysis of variance (P=0.10).

["CANADA THISTLE" continued on page 10]

Figure 1. Canada thistle growth stage at the May application timing. This growth stage is too early to apply Milestone herbicide, applicators should wait until early emerging plants are in the bud growth stage.

["CANADA THISTLE" continued from page 9]

RESULTS

Results of these studies showed that Canada thistle control was slightly more consistent with Milestone at 7 fl oz/A compared to Milestone at 5 fl oz/A.

Fall Application Timing: Milestone® and Tordon 22K resulted in similar or greater control when applied in September compared to October or November indicating that September may be the optimal time for fall applications (**Figure 2** and **3**).

Summer Application Timing: Canada thistle control with Milestone at 5 fl oz/A in Clark County was more consistent when applied in July and August compared to May, September and October. Canada thistle control with Milestone at 7 fl oz/A was significantly lower when applied in May compared to applications made from July through October (**Figure 4**). Canada thistle plants are not fully emerged in May, which reduces effectiveness of herbicide treatments.

CONCLUSIONS

Results of these studies indicate that the optimal time to control Canada thistle in the summer with Milestone herbicide is after Canada thistle plants are fully emerged in June through August. For fall applications, the optimal application time for Canada thistle control with Milestone or Tordon 22K herbicides is September when green basal re-growth is present. Milestone® at 7 fl oz/A was more consistent than lower rates of Milestone or Tordon 22K at later fall application timings of October and November. Additional articles on Canada thistle control with Milestone herbicide are available at www.techlinenews.com.

Effect of Milestone on Canada Thistle and the Native Plant Community in a Restored Tallgrass Prairie
http://techlinenews.com/fall2010_canadathistle.pdf

Tips for Managing Canada Thistle with Herbicide
http://techlinenews.com/2010tn_canadathistle.pdf

Tips for Fall Application of Milestone Herbicide Canada Thistle
http://techlinenews.com/CIRAR_FallAppTips.pdf

EDITOR'S NOTE:
This article summarizes a poster presented at the Western Society of Weed Science Annual Meeting, March 2012. The entire poster can be viewed on-line at: **http://techlinenews.com/denekeCT.pdf**

Figure 2. Canada thistle control one year following treatment with Milestone and Tordon 22K applied in September, October or November in Brookings County, South Dakota. Data bars with the same letters are not significantly different.

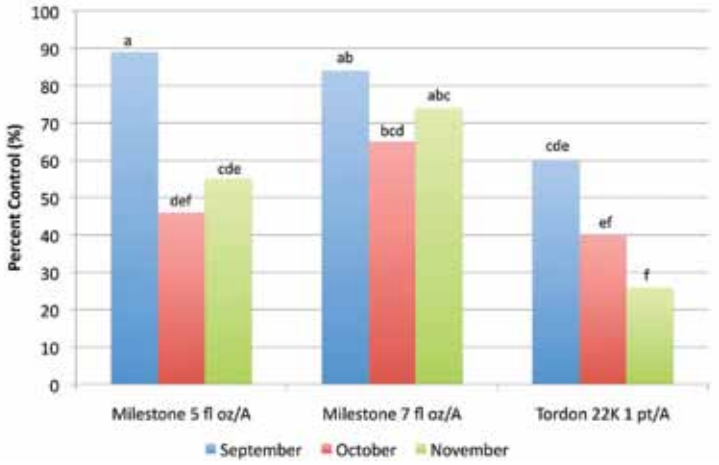


Figure 3. Canada thistle control one year following treatment with Milestone® and Tordon 22K applied in September, October or November in Clark County, South Dakota. Data bars with the same letters are not significantly different.

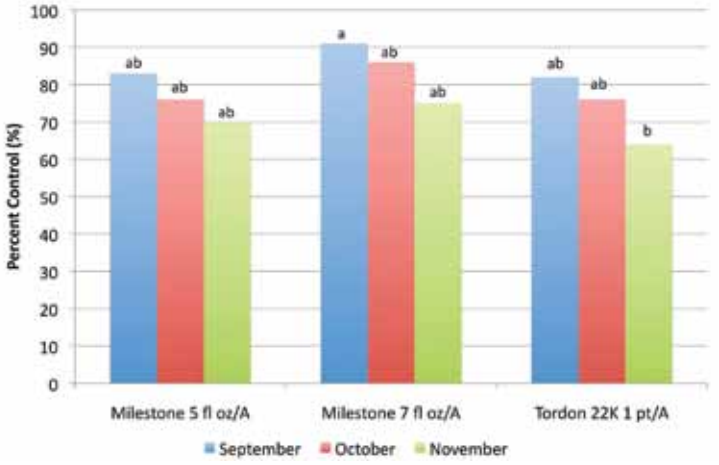
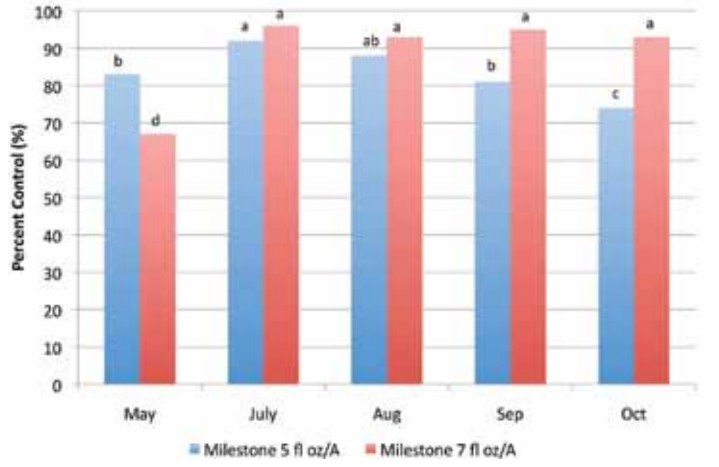


Figure 4. Canada thistle control one year after treatment with Milestone applied at 5 or 7 fl oz/A in May, July, August, September, or October in Clark County, South Dakota. Data bars with the same letters are not significantly different.



BIOLOGY AND MANAGEMENT OF

Common Teasel

by Celestine Duncan, TechLine Editor

Teasel (*Dipsacus sylvestris*) is a stout, tap-rooted biennial that grows up to six feet tall. The plant was introduced to North America from Europe, possibly as an ornamental or for use in wool processing. The common name "teasel" refers to the practice of using the dried flower heads to "tease" or card wool.

Teasel occurs throughout North America and is well adapted to moist, sunny habitats including prairies, savannas, seeps and sedge meadows, roadsides, railroads, and other disturbed sites. Teasel reproduces from seed, and first-year rosettes have dark green, toothed-edged leaves with a puckered surface. During the rosette stage teasel develops a large taproot that may extend more than two feet in length. Some plants produce flowers after growing for one year as a rosette, whereas others take three or more years to flower. Flowers are purple and borne in dense heads with each flower subtended by spine-like bractlets. Stems and flower heads become woody at the end of the growing season, persisting through the following winter and sometimes over several seasons. Seeds usually fall within five feet of the mother plant, although it is suggested that birds may aid long distance dispersal. An average teasel plant produces 3,300 seeds.

MANAGEMENT

The most cost effective treatment for teasel is the use of selective foliar applied herbicides. Studies conducted in Missouri, Oregon and Virginia showed that Milestone® rates of 4 to 7 fluid ounces of product per acre (fl oz/A) provided good to excellent control of teasel two to three months following treatment. Teasel control was 85 percent two months following application with Milestone at 4 fl oz/A and 99 to 100 percent three months after treatment with Milestone at 5 or 7 fl oz/A. Milestone herbicide should be applied in the spring and early summer to rosettes or bolting plants to stop seed production. The higher application rate of 5 or 7 fl oz/A is recommended for plants at the bolting growth stage.

Teasel can also be controlled with digging or cultivation. In natural areas or grasslands, small infestations can be effectively removed with hand tools. Be sure to remove the root crown to prevent re-sprouting. Flowering stalks can be cut slightly below ground level just as plants start to flower. Avoid cutting stalks prior to flowering since the plants will re-sprout and flower again. Inspect sites periodically and remove any plants that re-sprout from the crown. Mowing and prescribed burning are ineffective methods for controlling teasel, and no biological agents are available for the weed.

It is important to remember that several years of treatment will be necessary to eradicate teasel from a desirable plant community. Seed production must be prevented to deplete the soil seed bank.

Teasel flowerhead

Teasel stem with cupped leaves

Teasel rosette: The optimum growth stage for Milestone application is rosette to early bolt.

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Thanks for reading!
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